United States Tariff Commission

INFORMATION

CONCERNING

OPTICAL GLASS *and* CHEMICAL GLASSWARE

PRINTED FOR THE USE OF
COMMITTEE ON WAYS AND MEANS
HOUSE OF REPRESENTATIVES

WASHINGTON
GOVERNMENT PRINTING OFFICE
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UNITED STATES TARIFF COMMISSION.

Office: 1322 New York Avenue, Washington, D. C.

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LETTER OF TRANSMITTAL.

UNITED STATES TARIFF COMMISSION,
Washington, June 3, 1919.

The Committee on Ways and Means of the House of Representatives:

I have the honor to transmit herewith, in accordance with your request dated June 2, 1919, information compiled by the United States Tariff Commission on optical glass and chemical glassware.

Very respectfully,

THOMAS WALKER PAGE,
Vice Chairman.

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PART I.—OPTICAL GLASS.

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Part 1.—OPTICAL GLASS.

PARAGRAPH 494, TARIFF ACT OF 1913.

Paragraph 494.—Glass plates or disks, rough cut or unwrought, for use in the manufacture of optical instruments, spectacles, and eyeglasses, and suitable only for such use; provided, however, that such disks exceeding eight inches in diameter may be polished sufficiently to enable the character of the glass to be determined. (Free of duty. Act of 1913.)

SUMMARY.

DESCRIPTION.

Optical glass, rough cut or unwrought, is the essential element in the manufacture of microscopes, field glasses, range finders, gun sights, photographic lenses, and other optical instruments. It is admitted into the United States free of duty. Up to the end of the year 1917, this glass was not manufactured in the United States and had been imported in its unwrought state, principally from Germany, where many new varieties had been developed after years of scientific research and experiment. It has been imported also from France and England.

Optical glass in a finished state and as part of completed optical instruments is also free of duty, when such instruments are imported by educational institutions for their own use.

DEVELOPMENT OF A NEW INDUSTRY.

The shutting out of German imports and the necessities of the Allied Governments soon exhausted the supply of optical glass in the United States. In 1917 scientists of the Carnegie Institution and the United States Bureau of Standards cooperated with four American manufacturers and succeeded in producing certain varieties of optical glass which met the requirements of the Army and Navy.

These manufacturers have built and equipped factories for the production of the optical glass required for domestic consumption. The quantity needed for this purpose is not large either in time of war or peace, but that the industry is essential was established by our experience in the war.

In Germany, France, and England the industry has been expanded since 1914.

TARIFF CONSIDERATIONS.

The advantages possessed by Germany and other countries are such that this new American industry is unequal to successful competition with the countries named on the basis of continued free importation of the foreign product. American manufacturers desire the repeal of paragraph 573 of the tariff act of 1913, which admits, duty free, complete optical instruments imported, for scientific use in educational institutions for the reason that a very large part of the total domestic demand comes from these institutions.

STATUS OF THE INDUSTRY.

DESCRIPTION.

Optical glass of the highest grade is the essential element in the making of microscopes, field glasses, range finders, gun sights, periscopes, aiming circles, photographic lenses, and other optical instruments. While this glass is indispensable in directing and controlling the firing of modern artillery and of naval and military ordnance in general, the quantities needed for range finders, gun sights, trench periscopes, etc., are not great in any country, even in time of war. For microscopes, field glasses, and other instruments used in time of peace there will be a steady and increasing, though limited, demand.

DOMESTIC PRODUCTION.

The production of optical glass in the United States from April to October, 1918, inclusive, as shown by the War Industries Board, was as follows:

Optical glass plates or disks, rough cut or unwrought.

PRODUCTION IN UNITED STATES, 1918.

	April.	May.	June.	July.	August.	September.	October.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Ordinary crown	6,072.00	8,264.75	8,322.75	6,999.50	14,983.00	6,890.37	8,372.25
Boro-silicate	3,760.00	8,842.75	12,681.00	13,726.50	20,018.25	21,107.31	22,379.87
Barium crown	3,435.00	9,122.25	10,989.75	3,117.25	7,003.75	12,428.75	11,529.75
Light flint	7,914.50	10,255.75	22,397.00	21,845.25	21,175.00	12,765.37	25,731.31
Dense flint	5,272.00	7,791.50	24,835.00	7,291.75	23,973.25	15,327.50	21,516.25
Extra dense flint	488.00	1,511.50	4,220.25	3,972.00	2,454.50	15.50	6,034.25
Baryta flint	1,215.50	750.00	1,850.00	210.00	3,631.25	1,031.00	....
Very light flint	....	....	....	....	....	702.00	....
Total	28,157.00	46,538.50	85,295.75	56,862.25	93,239.00	70,267.81	95,563.68

Experimental work.—Prior to the year 1918 there was practically no production of optical glass in the United States. One American company built an experimental optical glass plant in 1912 and by 1914 was able to produce a few types of glass which were used in optical instruments. Manufacturers of optical instruments up to 1914 were able to obtain optical glass of the best quality from Europe, the general supply coming from three great firms, one in Germany, one in France, and one in England. But by the end of 1914 the importation of optical glass had become difficult and uncertain and three American firms and the Bureau of Standards began to experiment in making it. When the United States entered the war in 1917 the demands of the Army and Navy required the making of the glass in this country, and the scientists of the Geophysical Laboratory of the Carnegie Institution were called upon to aid the manufacturers in its production.

The beginning of the optical-glass industry in the United States and its development to meet the needs of the Government were stated to the Tariff Commission by Capt. F. E. Wright, Army representative of optical glass and instruments for the War Industries Board. Capt. Wright was in charge of optical-glass production for the geophysical laboratory of the Carnegie Institution of Washington:

Optical glass, although not required in large quantities, is nevertheless an important item in war operations, because by the use of optical instruments much of the firing, especially by artillery, is directed and controlled. If the men are not equipped with fire-control instruments and can not see to aim properly their firing can serve little purpose. This situation was not adequately realized by manufacturers in this country before the war, and little effort was made to produce optical glass. Manufacturers of optical instruments were able to obtain optical glass in desired quality and quantity from Europe, and consequently did not feel the necessity for making it themselves. In 1912, however, the Bausch & Lomb Optical Co., through the efforts of Mr. William Bausch, built an experimental optical-glass plant, and placed a practical glass maker, Mr. V. Martin, in charge. By 1914 this company was able to produce a few types of optical glass which were used in optical instruments. By the end of 1914 the importation of optical glass had become difficult and uncertain. Other firms, as Keuffel & Esser, Spencer Lens Co., and also the Bureau of Standards, began to experiment in making optical glass. By 1917, when the United States had entered the war, the optical-glass situation had become critical; the European supply was practically cut off; optical glass had to be made in this country if our Army and Navy were to receive the fire-control instruments which they needed. The geophysical laboratory of the Carnegie Institution of Washington was called upon to aid in the production of high-grade optical glass. A party from the laboratory was stationed, in April, 1917, at the plant of the Bausch & Lomb Optical Co., and for seven months all efforts of the laboratory were concentrated at this plant. By the end of 1917 the essential details of the manufacture had been developed, and glass in considerable quantities was being produced. The efforts of the laboratory were then extended to the Spencer Lens Co. and the Pittsburgh Plate Glass Co. At the present time large quantities of optical glass of the kinds needed for military fire-control instruments are being produced of a quality equal in practically every respect to the best European glass.

The production of this glass has been an urgent military necessity. The required information on details of manufacture has been gained at very considerable expense.

Difficulties encountered and progress made.—At the Pittsburgh hearings of the Tariff Commission statements were made explanatory of the difficulties encountered and the progress that had been made. In his testimony Dr. John A. Brashear said:

You do not know how we have been handicapped on account of lack of material to make the things that the Government is wanting so badly. I think we have refused to handle in our workshop over half a million dollars worth of orders from the Government because we had no way in which to fill them. Yet the Government needs those things. I think we have 99,000 pieces to make of this article [indicating small piece of glass]. There are 11 pieces to each article. I think we have orders for 9,000 sets, which would make 99,000 pieces. This instrument is a minature periscope to be used in the trenches to locate places from which shots are being fired and to locate those places within 4 or 5 seconds of an arc, and these pieces have to be made with a precision of which you have no idea. We must get the material, and those people are going to give it to us. The Pittsburgh Plate Glass Co. now has two Government experts from the Bureau of Standards, and the Carnegie Institution at Washington has sent either two or four of their men to give them, as far as they can, the chemical equivalents, the technique, and all that sort of thing. My little firm on the hill is doing everything it can to help.

At the present time, of course, we have none of the optical glass made by the Germans. They have developed 28 new kinds of glass, and one of those kinds was the glass that we use entirely now for range finders and for gun sights for the Navy, for which we now have orders for some 5,000. It is also used for the panoramic sight. I happen to have a couple of pieces of that glass here. Here is one of the pieces, which is a little bit soiled [indicating a small bit of glass]. Here is another piece [indicating glass]. This is made for what is called the panoramic sight, which requires a precision which would not have been dreamed of 20 years ago. This piece of glass [indicating] has to have its angle corrected to 2 seconds of an arc and its surface has to be correct to the one one-hundred-thousandths of an inch. Of course, we are able to do that; in fact, we can test them within one ten-millionth of an inch. The French have also taken that glass up and make it successfully.

To-day we are making instruments for the Army that will photograph the flight of a cannon ball. It took 40 minutes to take the first picture of the human face in 1839 and to-day, by the use of a photochronograph, we record the flight of a cannon ball. We can photograph it inside the gun or outside the gun for a great distance.

Materials.—In American factories the materials used in the manufacture of optical glass are silica, alkali, lime, lead, baryta, zinc, alumina, and boron.

The Bureau of Standards has developed clay crucibles in which the glass is melted and brought to perfection.

Domestic production and consumption.—While optical glass of the highest quality has been successfully produced and the capacity of factories has been sufficient to meet domestic needs, it is evident that the industry is not yet able to supply all the grades and kinds of glass for which there is a demand. In 1913 we imported optical plates and disks valued at $506,594, and in 1914 at $617,703, of which 50 per cent came from Germany and 27 per cent came from England. In 1917 the value of the imports was $238,258, and in 1918 there was an increase to $275,295. The decrease from former years in 1917 and 1918 is due in part to the establishment of this new industry in the United States.

FOREIGN PRODUCTION.

Statistics of foreign production are not available, but the potential power of foreign competitors is indicated in their export trade and in the great advantages they have had in the earlier scientific development of this product. The statistics of exports of this particular kind of glass are meager and not reported at all for some countries.

In 1913 Germany exported optical glass of various kinds, valued at $7,900,172, classified as follows: Rough optical glass, $271,320; lenses, $2,528,274; and other optical glass, $5,100,578. In the same year France exported lenses valued at $493,887, and other optical glass, $18,760.

The manufacture of optical glass requires scientific knowledge of a high order as well as exceptional skill. It is one of peculiar technical difficulties, both chemical and mechanical. Prof. Abbe, in Germany in 1876, in making an appeal for assistance and cooperation in the continuance of experimental work, said, "The future of the microscope as regards further improvement in its dioptric qualities seems to be chiefly in the hands of the glassmakers," and "not microscopy alone is here affected, but all sciences and arts that need optical appliances." This appeal resulted in a Government subsidy in aid of a scientific investigation in 1881, and after five years of research and experiment, the Germans were successfully engaged in the wholesale production of optical glass in a number of varieties. The formulæ and methods of production were kept secret, and a practical monopoly was established.

IMPORTS.

In 1913 optical glass plates and disks, rough cut and unwrought, of the value of $506,594, were imported into the United States. In the following fiscal year the value of the imports of this glass increased to $617,703; in 1915 they decreased to $495,179, and in 1916, 1917, and 1918 to $265,389, $238,258, and $275,295, respectively. In 1913 and 1914 the imports from Germany were 50 per cent of the total, while those from England were 27 per cent of the total. In 1918 the imports from England were 73 per cent of the total, and were also 40 per cent in excess of imports from England in 1913. English exports to the United States probably included reexports. Imports from Germany and Belgium have ceased. Imports from France in 1913 were 18 per cent of the total, and in 1918, 26 per cent.

Glass plates or disks, rough cut or unwrought.

IMPORTS BY COUNTRIES.

[Fiscal years.]

Imported from—	Imports of plates or disks (optical glass), rough cut or unwrought, for optical purposes.					
	1913	1914	1915	1916	1917	1918[1]
England	$141,898	$159,851	$184,031	$174,926	$190,096	$200,066
France	92,977	98,832	52,028	60,934	39,762	71,235
Belgium	18,894	68,354	12,164	....	....	....
Netherlands	....	....	1,630	....	....	....
Germany	249,471	290,154	244,632	18,982	6,197	....
Austria-Hungary	127	198	....	....	....	....
All other	1,227	314	694	10,547	2,203	3,994
Total	504,594	617,703	495,179	265,389	238,258	275,295

Imported from—	Imports of lenses and other optical instruments (including spectacles).					
	1913	1914	1915	1916	1917	1918[2]
United Kingdom	$103,992	$40,126	$15,414	$7,861	$8,366	$18,483
Japan	235	207	111	1,331	8,302	24,871
France	392,513	403,801	165,948	128,895	121,068	69,177
Belgium	4,161	14,807	4,099	....	....	....
Netherlands	103	6	683	258	4	....
Germany	173,813	237,596	104,473	10,478	962	....
Austria-Hungary	16,592	20,794	6,898	123	22	....
All other	3,726	4,223	5,345	17,820	7,537	4,118
Total	695,135	721,560	302,971	166,766	146,261	116,649

[1] Imports during the 6 months ending December, 1918, $170,762.
[2] Imports during the 6 months ending December, 1918, $77,239.

In addition to the imports of unmanufactured optical glass, large amounts are imported in a manufactured condition as the essential parts of lenses and other optical instruments, including spectacles. In 1913 the value of the imports of lenses and other optical instruments, including spectacles, was $695,135, and in 1914, $721,560. In the years following, these imports have gradually decreased to $116,649 in 1918. From France in 1913 these imports were 56 per cent of the total, from Germany 25 per cent, and from England 14 per cent. For the six months ending December, 1918, the imports of unwrought glass were $170,762 and of lenses and other optical instruments $77,239, both showing decided increases over the previous year.

COMPETITIVE CONDITIONS AND TARIFF CONSIDERATIONS.

This new industry in the United States has the materials, the scientific knowledge, the equipment, and the capacity to compete with some of the best products of foreign manufacture. During the past three years Germany has been shut out of our market and American manufactures have perfected and increased their output.

We have not as yet produced all of the varieties required for domestic consumption; we are still (1918) obliged to import about one-half of the normal amounts (1913–14) of unwrought and rough cut optical glass and in addition large quantities of optical glass in a finished condition as parts of optical instruments. In December, 1917, we were making but a few fundamental varieties of optical glass. At that time a scientific authority [1] stated that "The four most necessary varieties of glass, to wit, a very light and transparent crown suitable for field glass prisms, an ordinary crown of slightly higher index, a typical heavy flint, and a typical light flint, are already in production. The two next in importance are a heavy baryta crown and a light baryta flint used particularly in photographic lenses, and these, we learn, are under way, with every prospect of reaching suitable commercial developments. If a good supply of well annealed material, even of the half-dozen sorts here enumerated, can be had, the country will be in pretty good shape to make its own optical instruments. The matter of suitable mixing and annealing for the production of disks of large size may be trusted to the future."[2]

It was not until after five years of scientific research and experiment that the Jena works, of Germany, developed 28 new kinds of optical glass. This firm had the advantage of 25 years' experience in producing optical glass and in this field was practically without a competitor. It is not reasonable to expect that American manufacturers and scientists could, in less than three years, attain the required standards of knowledge and efficiency to meet the demands of domestic consumption and the inroads of foreign competition.

During the war the optical industries of Germany, France, and England have been driven to a high state of industrial activity and the scientific precision essential in the production of perfect optical glass. Under the tariff act of 1913 optical glass is admitted free of duty into the United States. The new American industry under such conditions is unequal to the task of engaging in successful competition with the output of the highly developed industry and the experienced scientists and manufacturers of the countries named.

Under paragraph 573 of the tariff act of 1913, the optical glass imported in a finished state as part of optical instruments is also free of duty when imported by educational institutions for scientific use and for experimental purposes.

Unwrought optical glass producers desire adequate protection for their new industry in order to stimulate greater production for educational and commercial requirements and for the further development of optical scientific instruments of the finest accuracy. They ask for the repeal of paragraph 573 which admits such instruments free of duty to educational institutions.

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[1] Metallurgical and Chemical Engineering Journal, Dec. 15, 1917.
[2] In February, 1919, all types of glass were being made. See p. 15.

METHODS OF OPTICAL GLASS MANUFACTURE.

The usual practice in the manufacture of optical glass consists of the following sequence of furnace operations:

The pot is carefully preheated in a small subsidiary furnace called a pot arch; from there it is "set" or transferred to the furnace. The pot is usually set at a temperature of about 1,050° C., and it must be heated up to the melting temperature of the glass batch, about 1,400 degrees for most glasses, before filling. The best practice is to overburn the pot before commencing the fill.

The batch, or batch mixed with cullet, is fed into the pot in several installments, until the fill is complete. The details of this process differ from plant to plant.

After the fill is complete, the glass is left undisturbed for several hours, primarily to give time for the bubbles to rise to the surface. The temperature during this period is high; in some places it is the practice to use a higher temperature for the fining operation than for the fill.

After the fining period is complete, it is customary to stir the glass by hand, intermittently; a common schedule is to hand stir for 15 minutes every two hours. This process removes the bubbles of gas adhering to the side and bottom of the pot, and helps to secure uniformity in composition.

After the period of intermittent hand stirring is complete, the glass is stirred continuously, a stirring machine being used. As a rule, soon after putting on the machine, the fire is turned off and the glass allowed to cool, stirring being continued until the pot is removed from the furnace. The operations summarized above take from two to three days in the furnace, the actual time depending on local practice. When, as is usually the case, the empty pots are preheated in pot arches, and the finished glass cooled in an appropriate subsidiary apparatus, a melting furnace will yield one pot of glass every two days.

New schedule doubled production.—After considerable experience in manufacturing optical glass, certain of the usual operations seemed to be inadequate or illogical, and soon after taking charge of the optical glass plant of the Spencer Lens Co. for the War Industries Board, I devised a new schedule radically different from the above, which may be called the "24-hour" process. Because of its importance in practically doubling the production of optical glass, a basic material in the manufacture of fire-control instruments the details of the process were communicated to the military optical glass and instrument section of the War Industries Board, and were communicated by them to the other manufacturers of optical glass.

In the first place, the filling operation required modification. Melting of the batch takes place from the top downward; the upper layers sinter together, then the more easily fusible components trickle down, leaving the upper layers impoverished in the substances usually called "fluxes." This results in the surface becoming high in silica; this is proved by skimmings from both crown and flint batches, which not only showed an actual accumulation of partially dissolved quartz grains, but also had a refractive index lower than that of the rest of the glass

Harmful effects of fluxes settling to the bottom overlooked.—The fluxes, especially lead, tend to settle to the bottom; this is proved by the dark layer always brought up when hand stirring is begun, by tests made by plunging a long iron rod into the glass and quickly withdrawing it, and by the examination of partially melted pots which have been removed from the furnace because of leaks and breaks after cooling. In the latter case the preponderance of silica mentioned above has also been observed.

This initial inhomogeneity, it is true, is removed by the subsequent stirring operation, and this probably accounts for its harmful effects having been overlooked. One of these harmful effects, especially in flint glasses, is due to the fact that lead-rich mixtures (for example, the extra-dense flints) are extremely corrosive on the pots. By the older process this lead-rich layer is allowed to lie on the bottom of the pot throughout the filling and the fining periods, both of which periods are of some hours' duration and of extremely high temperatures. This necessarily results in greatly increased pot corrosion. In addition, the impoverishment of the upper layers in fluxes increases the time required for complete solution of the batch ingredients.

Stirring during fill the remedy.—The obvious remedy is to stir during the fill. This is not feasible until the pot is a little over half full, because the stirring rod can not be floated before this, but as soon as feasible it should be begun, and the melt should be stirred each time a new batch is added. Making such a stir during the fill should diminish pot corrosion, give glass of a better quality, freer from color, striæ and stones, and should hasten the solution of the batch and thereby shorten the melting process. After the fill is completed, the glass must be freed from bubbles of gas arising from the decomposition of carbonates and nitrates in the batch and from the water in the batch ingredients. In some cases these volatile components comprise one-fifth of the weight of batch filled. By the old process the bubbles are mainly removed during the fining operation, the glass being kept hot and undisturbed for some time to allow the bubbles to rise to the surface. The intermittent hand stir following supplements the fining period by removing the layer of bubbles which adheres to the pot walls, and also tends to secure uniformity in composition throughout the melt.

Stirring the logical way to remove bubbles.—That seemed an illogical way to secure the desired result. In the first place, common experience is that bubbles in other liquids are more rapidly removed by stirring than by quiescence. It seemed reasonable to suppose that in a pot of glass also the bubbles will be more rapidly removed by stirring. Moreover, in the usual process the glass is not homogeneous in composition until after the fining period; the upper layer is deficient in fluxes, and hence melts less rapidly than the mass of the glass. The margin in composition between an unworkable viscous glass and a workable glass is a narrow one; the stirring should prevent the upper portion being deficient in fluxes and hence too viscous to permit the free passage of bubbles. It seemed a reasonable supposition, therefore, that two of the operations to which optical glass is usually subjected could be dispensed with, namely, the long fining period and the period of intermittent hand stirring. In other words, it seemed that better results could be obtained by putting on the stirring machine immediately after the fill, and stirring continuously until the glass was free from bubbles. With this modification could well be combined a hand stir during the fill, as mentioned before.

Results prove reasoning good.—The best test of this reasoning is the results. The new schedule was tried out on a melt of flint glass having an index of 1.617. The melt was run at the usual temperature for this glass, 1,390° C. Fills were made at two-hour intervals, the first fill being about one-third of the total batch, and on each subsequent fill the pot was heaped up with batch. As soon as possible a hand stir was made; 10 hours after the first fill the stirring machine was put on; at this time there was still undissolved batch, not all quartz. The stirring machine was run at a good speed, both with a circular and with a vertical motion.

After six hours the glass seemed free from bubbles; the fire was accordingly turned off and the pot cooled and removed as usual. The entire process, from the time the pot was set until the melt was out of the furnace and another pot set, was 24 hours. When the glass was examined it proved to be of the best quality, wholly free from bubbles, of greatly improved color, and also freer from striæ than usual.

Special schedules for different types of glass.—The details of the process were subsequently modified, and special schedules were worked out for the different types of glass. Following is a sample schedule, being that for a flint having $N_d = 1.617 - 36.5$. The pot used is 26 inches high and 28 inches in diameter, inside dimensions. The time of filling in the cullet is taken as zero hour.

Schedule for MF glass.

[Run at 1,390° C.]

Hours.	
0. 00	Add cullet.
1. 00	Fill pot three-quarters full of batch.
2. 30	Fill pot with batch.
4. 00	Hand stir; fill pot with batch.
5. 30	Hand stir; fill pot with batch.
7. 00	Hand stir; fill pot with batch.
7. 30	Stirring machine on.
15. 00	Gas off.

When cooled to the proper temperature the pot of glass is removed from the furnace, and slowly cooled in a pot arch. A new pot is set into the furnace, and given a preliminary burning, so that in 24 hours all is ready for another melt.

It may be well to emphasize one point of difference between the longer process and the 24-hour process. In the former the melt, often with an unduly corrosive layer on the bottom, remained in contact with the hot pot for from 20 to 30 hours from the time the last fill was made until the gas was turned off; in the 24-hour process the corresponding period of maximum corrosive action is 5 to 6 hours. As the majority of the contamination of glass, with our present raw materials, comes from the pot, the superiority of the newer process is obvious. Better color results from smaller pot contamination, as well as a greater freedom from atriae, less trouble from stones and less pot breakage.

Process proving a success.—The first experimental pot of glass made by the 24-hour process proved a complete success. Since that time some 350 pots of glass have been made by the shorter schedule. They comprise practically all types of glass; flints, from an extra dense flint with refractive index of 1.76 to an extra light flint with index of 1.55; soft crowns and ordinary crowns of three different types; several types of borosilicate crown; several barium crowns, both light and dense, and several baryta flints, ranging from a light baryta flint with index 1.56 to a dense baryta flint, index 1.62. Without exception the new process has produced a better glass than the old, with a doubling of production and correspondingly lower cost. (George W. Morey, general manager of Spencer Lens Glass Plant, Hamburg, N. Y., and late expert of Geophysical Laboratory, Washington, D. C.)

Recent improvements.[1]—The usual practice is to allow the melt to cool in the pot and the latter is thereby destroyed either during cooling or in breaking up and sorting the glass. An improvement by an American manufacturer, which has been successfully applied, consists in the casting of or pouring the melted optical glass on large casting tables, upon which it is rolled out before annealing in a large sheet, in the same manner as in the making of plate glass. This sheet or plate is then ground and polished, defects cut out, and the remainder cut to size for final inspection and selection of suitable lens pieces.

Hand stirring of the glass in the pot has been the European practice and also American, because of the care required in the operation. Motor-driven stirring apparatus has been adopted to take the place of hand stirring. It has been found that it is necessary to have sand with less than one two-hundredths per cent of iron content.

[1] Harrison E. Howe in Chemical and Metallurgical Engineering.

Part II.—CHEMICAL GLASSWARE.

PARAGRAPHS 84 AND 573, TARIFF ACT OF 1913.

That part of paragraph 84 which includes chemical glassware is italicized in the following:

"Glass bottles, decanters, and all articles of every description composed wholly or in chief value of glass * * * *and all articles of every description*, including bottles and bottle glassware, *composed wholly or in chief value of glass blown either in a mold or otherwise*" * * *, 45 per cent ad valorem.

Chemical glassware is admitted free under paragraph 573.

Philosophical and scientific apparatus, *utensils*, instruments, and preparations, including bottles and boxes containing the same, specially imported in good faith for the use and by order of any society or institution incorporated or established solely for religious, philosophical, educational, scientific, or literary purposes, or for the use of any college, academy, school, or seminary of learning in the United States or any State or public library, and not for sale, and articles solely for experimental purposes * * *.

SUMMARY.

DESCRIPTION.

Imported chemical glass utensils are dutiable at 45 per cent ad valorem under paragraph 84 of the tariff act of 1913 if used for manufacturing and commercial purposes. They are duty free under paragraph 573 of the act of 1913, if imported for the use of educational institutions. They are essential for the chemical control of a number of industries through their use as utensils in laboratory tests and analysis. The chemical departments of universities and other educational institutions use a large proportion of this ware in the courses of instruction given to the students of chemical and allied subjects.

ESTABLISHED AS A NEW INDUSTRY.

Prior to 1915 practically all of this ware was imported mainly from Germany and Austria. Since that time it has been established as a new industry in the United States. Factory blown ware, such as flasks, beakers, tubing and blanks, is now being made in seven old-established glass factories. Lamp-blown and volumetric ware and apparatus are being made in upward of 10 shops.

Scientific tests made by the Bureau of Standards in 1918 established that the flasks and beakers made in the principal American factories equaled in all cases, and surpassed in some, the best qualities of imported ware. Not only are American factories now fully supplying the domestic demand, but during 1918, they exported chemical glassware valued at $179,682 to more than 17 foreign countries.

Estimates of imports in 1913 range from $1,200,000 to $1,500,000, and of these from 42 to 53 per cent were imported free of duty to educational institutions.

TARIFF CONSIDERATIONS.

The manufacturers that have established this new industry in the United States since 1914 are satisfied with the existing rate of duty of 45 per cent ad valorem, but urge that the provision in paragraph 573, which admitted about half of the total chemical ware imported free of duty, be repealed and that all chemical ware be made dutiable at 45 per cent ad valorem. They state that this is necessary in order to encourage and build up their new industry; that large quantities of the ware used in educational institutions are not required to be of a high grade, and therefore the cheaper ware will be imported free of duty when normal trade conditions are restored; and that while they can compete under the existing rate of 45 per cent, they can not compete with duty free ware.

STATUS OF THE INDUSTRY.

DESCRIPTION.

Chemical glassware usually designated as "hollow glassware" or ware made in a glass factory operating a furnace, and including flasks beakers, tubing, reagent bottles, and other blown articles and blanks for volumetric ware, and also ware made from tubing before the blast lamp and groups of graduated ware, as burettes and pipettes, extraction apparatus, condensers, and other articles, when imported for manufacturing and commercial purposes, are dutiable at 45 per cent ad valorem under paragraph 84 of the tariff act of 1913. When these classes of chemical glassware are "specially imported in good faith for the use and by order of any society or institution incorporated or established solely for religious, philosophical, educational, scientific, or literary purpose" they are admitted free of duty.

Many of our most important industries requiring research work—the testing of processes and the analyses of their materials and products—are dependent upon chemical and scientific glassware for their successful continuance. Laboratory tests and analyses by means of this ware are essential in the chemical control of such varied industries as iron and steel, raw and refined sugar, packing-house products, fertilizers, rubber manufacture, Portland cement, soap, oil refining, waterworks, textiles, and in chemical plants in the manufacture of explosives, dyes, soda, and other products.

DOMESTIC PRODUCTION.

Quantity.—Before the war, practically all of these different classes of ware were made in, and imported from Germany. Beginning with the year 1915, factory-made blown ware, such as flasks, beakers, tubing, and other articles have been made in about 10 large and well-organized glass factories in the United States. Flasks and beakers have been made in one American glass factory since about the year 1900, but in very inconsiderable quantities. Since 1915 the cutting off of imports has induced domestic factories to enter upon the production of this class of ware. Lamp blown and volumetric ware is being made in a large number of shops, comparatively small in size. The value of the chemical ware produced in American factories and shops has been as follows: 1915, $950,319; 1916, $1,661,121; 1917, $2,233,704; 1918, $2,865,774.

Classification of products.—In an address on "The Manufacture of Chemical Apparatus in the United States" delivered before the American Chemical Society at its meeting held at Urbana, Ill., April 18–21, 1916, Mr. Arthur H. Thomas, an importer, exporter, and dealer in laboratory apparatus of both foreign and domestic manufacture, made the following classification of chemical glassware:

HOLLOW GLASSWARE.

Articles.—Flasks, beakers, and other factory-made shapes, including blanks for some volumetric ware. Tariff, 45 per cent ad valorem.

Sources before the war.—With the exception of one large factory in the United States which made, in addition to extensive products in other lines, a few flasks, and beakers of excellent quality and reasonable price, this ware was purchased exclusively in Europe. The American production was not, in any commercial sense, a factor in the situation.

LAMP-BLOWN AND VOLUMETRIC WARE.

Articles.—All shapes made of tubing before the blast lamp, including the graduation of blanks made in the factory in addition to those made before the lamp. Tariff, 45 per cent ad valorem.

Sources before the war.—With the exception of a few items not of significance to our discussion, such as hydrometers and thermometers for clinical and industrial use, homeopathic vials and test tubes, milk bottles, and syringes, all staple stock was purchased in Europe. Repair work and the manufacture of a great variety of special items, not in sufficient demand to warrant arrangement for importation in large quantities, was conducted in a few glass-blowing shops operated by some of the larger dealers, in separate small shops in a few of the larger cities, and in the south Jersey district as an important side line in connection with three large glass factories.

OPTICAL MEASURING INSTRUMENTS.

Articles.—Spectroscopes and spectrometers, polarimeters, and saccharimeters, refractometers, colorimeters, and microscopes. Tariff, 35 per cent ad valorem, except on microscopes, 25 per cent.

Sources before the war.—The instruments in this classification as used in chemical laboratories were all purchased in Europe with the exception of microscopes, the manufacture of which has, as you all know, been extensively and successfully conducted in America for many years.

Materials.—Sand, borax, and boric acid are the chief materials reported by one of the principal manufacturers. Other materials named are lime, soda ash, arsenic, and all are of domestic origin. Potash is not an essential ingredient.

Equipment.—The ordinary equipment of a glass factory for the blowing of bulbs and bottles suffices for the production of chemical hollow blown ware. Molds, blow pipes, and furnaces constitute the principal equipment, and are the same in all countries.

Methods and processes.—The making of hollow blown chemical ware is similar to that of incandescent lamp bulbs and bottles. Lamp-blown and volumetric ware made from tubing, and often according to the designs of laboratory scientists, and from the factory blanks is the work of specially trained artisans. There are less than 250 workmen of this class in the United States (1916) who have been for the most part brought from the Thuringian factories of Germany. Since the war one American firm has developed the use of machinery to do in part what was laboriously done by hand in Germany in the manufacture of the great variety of products coming under the head of "lamp-blown and volumetric ware."

Organization and capitalization.—There are no factories engaged exclusively in the production of chemical hollow glassware, and in the large, well-organized and long-established factories where it is made, it is not a major product. Its manufacture is dependent upon the existing organization and capitalization of the factory.

Geographical distribution.—The principal hollow ware factories are located in New York, Pennsylvania, and New Jersey. The lamp-blown and volumetric shops, a few of them connected with factories, are in New York, Pennsylvania, Illinois, and New Jersey.

Domestic production and consumption.—Since 1915 there have been no imports of chemical glassware, and the domestic production at this time (February, 1919) is fully equal to the demands of domestic consumption. The exports of this ware though small, indicate that the existing factories are meeting our requirements. The shortage of the highly skilled labor required for the making of lamp-blown and volumetric ware makes it doubtful if American shops can meet the domestic requirements for this class of ware.

The following table shows the production of chemical glassware in the United States for the period 1915–1918. The figures are compiled from the reports of manufacturers to the Tariff Commission:

Year.	Factory-product value.	Shop-product value.	Total value.
1915	$748,440	$201,879	$950,319
1916	1,279,178	381,943	1,661,121
1917	1,560,046	673,658	2,233,704
1918	1,910,109	995,665	2,865,774

Exports.—For the first time in its history the United States has become an exporter of domestic chemical glassware. During the calendar year of 1918, chemical glassware, valued at $179,682, was exported to 17 specified foreign countries and to others not specified. Canada, Cuba, Mexico, and China, in the order named, were the destinations of about 60 per cent of the total. During the six months ended December 31, 1917, the value of exports of this ware was $65,336, this being the first export recorded. It is believed that a shortage of the ware in these countries, formerly buyers from Europe, was the cause of the exports, and that the bulk of this trade will not be permanent.

Domestic exports of chemical glassware.[1]

Exported to—	6-month periods ending—		
	December, 1917.	June, 1918.	December, 1918.
Italy	$3,215	$2,302	$85
Canada	22,144	21,315	21,759
Mexico	4,754	6,279	7,224
Cuba	10,833	15,187	17,737
Argentina	2,052	2,747	3,516
Brazil	2,936	2,874	5,014
Chile	1,465	5,139	3,014
Peru	627	1,341	2,236
Uruguay	220	2,320	....
Venezuela	524	1,192	3,036
China	664	8,216	3,799
Dutch East Indies	2,272	2,858	6,091
Australia	540	5,890	1,548
Philippines	1,215	2,305	970
All other	21,865	7,636	[2] 16,052
Total	65,336	87,601	92,081

[1] First shown in July, 1917.
[2] Made up principally as follows: England, $3,600; British South Africa, $3,206; and British India, $3,206.

FOREIGN PRODUCTION.

There are no available statistics of foreign production. Jena, Germany, occupies first place in the production and export of this ware and it was there it was successfully developed. It is also made and exported from Austria, Belgium, and France. In 1911 Germany exported to all countries chemical ware valued at $1,946,126. The exports of Austria have been considerable, but are not ascertainable.

IMPORTS.

Before the war the total domestic consumption of the United States was imported, except a very small quantity made as a by-product in a New Jersey glass factory.

Statistics of the imports of chemical glassware have not been reported separately for many years. Estimates of the value of the imported ware before the war by the two principal importing houses, for the year 1913, place it at from $1,200,000 to $1,500,000; of these totals the value of the ware imported free of duty for educational institutions the same year was from $500,000 to $800,000, or from 42 per cent to about 53 per cent.

TARIFF HISTORY.

Paragraph 573 of the act of 1913 exempts from duty chemical glassware as philosophical or scientific apparatus, utensils, or instruments for educational and like institutions. This exemption dates back to the act of 1790. Enlargements of the classes of goods or institutions were made in the acts of 1816, 1824, 1841, and 1842. The provision was omitted from the act of 1846 and also from 1864 to 1870, since when free entry has been uniformly accorded.

Three rules of construction have competed, each at times successfully, in litigation. First, intrinsic character of the article; second, chief use of the article; and, third, intended or actual use of the particular importation. The last was held by the Court of Customs Appeals to be the proper rule. (*United States* v. *Kastor*, 6 Ct. Cust. Appls., 52.)

TARIFF CONSIDERATIONS.

There has thus far been no competition. Prior to 1915 practically all of this ware was manufactured in and imported from Germany. In 1915 American factories began to produce the ware as a new industry and there have been since no importations.

Under paragraph 573 of the tariff act of 1913, chemical glassware imported "for the use and by order of any college, academy, school, or seminary of learning in the United States or any State or public library and not for sale" is admitted free of duty. It has also been admitted free of duty for educational and scientific purposes under various tariff acts, from 1790 to 1846, from 1857 to 1864, and from 1870 to 1913. If imported for purposes other than those stated above, it is dutiable under paragraph 84 of the tariff act of 1913 at 45 per cent ad valorem.

At the Pittsburgh conference of the Tariff Commission in January, 1918, manufacturers who began the making of this ware when our supply was cut off from Germany, and who are now supplying the domestic demand, strongly objected to the importation free of duty of laboratory ware for educational institutions.

They pointed out that although the high grades of this ware now being made in the United States are superior, according to the tests of the Bureau of Standards, to the Jena and other European ware, and will be given preference on account of their merit, yet large quantities of the ware are not required to be of a high grade and therefore American educational institutions, after normal trade conditions are restored, will import the cheaper ware duty free, and American manufacturers will not be able to compete with duty-free ware. They ask that the duty-free proviso on chemical ware be stricken out, and they further state that if the existing tariff rate of 45 per cent is maintained on all the chemical ware that comes in, they can compete. One manufacturer made the following statement: "We considered that question very carefully before we proceeded to produce laboratory glassware, and concluded to venture, believing that our Government would protect us after the war."

Comparative tests of foreign and domestic ware.—Chemical glassware of good quality is characterized by special powers of withstanding heat and chemical attack.

Comparative tests of chemical glassware were made in 1918 by the experts of the United States Bureau of Standards of brands of American-made ware and the best-known wares of European manufacture. The following is from the official report of the Bureau of Standards:

The cutting off of our imports from Germany and Austria has forced us to rely upon American manufacturers for practically our entire supply of glass beakers and flasks. In order to give chemists some information as to the quality of this ware, the Bureau of Standards has examined five brands of American-made ware in comparison with the two best-known wares of European make.

The tests included chemical analysis; determination of coefficient of expansion; refractive index; condition of strain; resistance to repeated evaporation, to heat, and to mechanical shock; and resistance to chemical reagents.

In all cases of beakers and flasks approximating in size the 400 cubic centimeter Jena beaker and flask were used. All the ware tested bore permanent trade-marks. From 45 to 50 beakers and flasks of each ware were secured for this series of tests.

General summary of tests.

Name of manufacturer.	Resistance to—						
	Water.	Mineral acids.	Carbonated alkalies.	Caustic alkalies.	Ammonia and ammonium salts.	Heat shock.	Mechanical shock.
Kavalier	Poor	Good	Poor	Good	Good	Poor	Poor.
M. E. G. Co.[1]	Good	...do	Good	...do	...do	...do	Do.
Pyrex [1]	...do	...do	...do	Fair	...do	Good	Good.[2]
Jena	...do	...do	...do	...do	...do	...do	Fair.
Nosol [1]	...do	...do	...do	...do	...do	...do	Do.
Fry [1]	...do	...do	...do	...do	...do	Poor	Good.
Libbey [1]	...do	...do	...do	...do	...do	Good	Do.

[1] American. [2] Far superior to any of the other wares.

In the rating of resistance to caustic alkalies the boiling tests only have been considered. These results indicate that all the American-made wares tested are superior to Kavalier and equal or superior to Jena ware for general chemical laboratory use.

VIEWS OF MANUFACTURERS, SCIENTISTS, IMPORTERS AND OTHERS.

TARIFF COMMISSION CONFERENCE WITH GLASS MANUFACTURERS.

At the conference of the Tariff Commission with glass manufacturers at Pittsburgh, Pa., in January, 1918, the following statements relative to chemical glassware were made by the manufacturers named:

J. H. Fry, vice president of the H. C. Fry Glass Co., Rochester, Pa.:

Before the war, the chemical ware came principally from Germany. The price of that ware landed in this country was so low that there was no inducement to the manufacturer to make it. In fact, we never figured that we could compete in that field as long as we had to compete against the foreign ware.

These two lines have increased our factory production about $200,000 in the last year.

The technical problem in the chemical glass industry is to secure the proper mixture of materials and the required skill in manufacture. We had trouble in getting skilled labor with technical experience. It took us about six months to really get a production that was satisfactory.

A large quantity of chemical ware is used by the laboratories and colleges of the United States. If that ware comes in duty free, as under the conditions existing prior to the war, we can not compete. It is necessary to have tariff protection on that ware if we are to maintain the quality that we are now manufacturing; and it was necessary to get a good quality in order to replace the foreign ware. We can sell a limited amount to the mills and factories, but as a rule, I do not think we would be justified in manufacturing either the quality or the large line that we are now making. The chief quantity consumed is used in the scientific and educational institutions. We have always felt that the colleges should pay a duty the same as anyone else on this ware. They should pay a duty, just the same as they have to pay the price on iron or anything else to build their buildings. We have to support the colleges, and the colleges in turn, I think, should support the manufacturers. We are always making donations to colleges, and it does not seem fair to have them buying one of their principal articles from the other side.

The German manufacturers had the materials, they had the skilled labor and they had the jump on us in producing this ware. We are getting the jump on them now because they are eliminated entirely. It remains to be seen what the effect of the war will be from the labor standpoint, and as to whether or not they will overtake us in manufacturing after the war. Of course we do not know. The reason that they had the advantage then was that the American factories could not compete. We have now proven that we can make a high quality of laboratory ware at reasonable prices.

To a certain extent there was a special prestige for German chemical ware in this country, which had to be overcome. Many of the chemists were Germans. This ware did not all come from Germany; some of it came from Austria. I know of only one factory in the United States that made any headway in that particular line prior to the war, and they manufactured principally such articles as are used by the drug trade. That was the Whitall-Tatum Co. Since the war five or six American factories are making chemical glass, and it keeps the price down to a competitive basis. There are eight or ten new furnaces operating on that line of ware.

The production in Germany was quite large. In the limited time we have been in this business our sales will run over $150,000 a year.

When we decided to go into this line, we employed the best chemists we could find. The idea was to get quality, so that after the war our quality would be known and we would have a chance to sell it on a quality basis. We experimented with it, and we made glass which from all chemical standpoints was superior to the original German production. The ingredients and the way they are made are somewhat different. It is a superiority that we hope will continue indefinitely, because the demand in this country has been for a better quality. The distinctive requirement is for quality glass that will stand the laboratory tests. The first test applied by the Bureau of Standards was that of water, the second that of mineral acids, the third carbonate alkalies, the fourth caustic alkalies, fifth ammonia and salts of ammonia, sixth heat shock, and finally mechanical shock. The chemical glass meeting those tests naturally would be known as a quality line. The workmanship does not count as much as the resistance to heat and chemicals, to withstand sudden changes of temperature and the attack of reagents.

I believe that if the present tariff duty on this line of goods is maintained and collected from all impartially it will not be necessary to increase it. We can manufacture the goods here to compete successfully against glassware that will be imported after the war, provided that duty will be imposed on all who use the glass. It seems unfair to have chemical glass come in duty free to universities and educational institutions, for if they buy imported instead of American glassware our production is correspondingly decreased, and the cost of production is thereby made higher. That is, a large production is necessary to keep costs down. If we have to limit ourselves to a smaller field of distribution, we shall have to get a higher price. On the other hand, if the tariff is maintained on all glassware that comes in, regardless of the purchaser, I might say that so far as our plant is concerned we can compete. We considered that question very carefully before we proceeded to produce laboratory glassware and concluded to venture, believing that our Government would protect us after the war. That is the reason we set out to produce a high-quality line of ware and spent about $10,000 in its development.

I do not believe that the rate of 45 per cent ad valorem could be reduced without harm. It was only through getting the experience we have had which enables us to manufacture the ware now in quantities, that we felt warranted in going ahead and spending money for equipment and getting ready to stay in the business after the war. By that I mean we felt that the 45 per cent duty ad valorem would protect us and let us compete in that line after the war if conditions were about the same as they were previous to the war. It requires special equipment largely. We had to invest capital for this equipment.

After the war some of the machinery could be reconstructed so as to be used in other lines, but most of it would be lost. All of the molds would be an absolute loss. That would be true because of the nature of the product. It is very hard and requires a different method of finishing than ordinary glass.

I imagine we spent $10,000 before we were able to produce any glass. For instance, a man will melt a pot of glass and then throw it away, or something like that, and I would simply estimate that it cost us about $10.000 to get it on the market. The Government is a very large user just now in our line.

Howard S. Evans, vice president of the Macbeth-Evans Glass Co., Pittsburgh, Pa.:

I would like to take up the question of the laboratory glassware. There was scarcely any of this line manufactured in this country before the war, but since the outbreak of the war our manufacturers have begun to produce all kinds of glassware for laboratory use. Some of the manufacturers are producing a quality which is equal to, and in some respects excels, the foreign product. We have entered into the manufacture of it very largely.

It has seemed to me to be rather unfair to the manufacturer in this country to permit the importation of this line of goods duty free. In fact, that has been the reason why most of the manufacturers did not enter this particular field. There is one concern, Whitall-Tatum & Co., that made these goods in a small way.

I wish to say that I thought it was not quite right to the American manufacturers to allow the free importation of laboratory glassware and apparatus for use in colleges and universities. They are very large users of the product, and if their business was not obtainable there would be not enough left to justify the manufacturers in making the molds and putting in the equipment for the remaining business: that is, for glass that would be used industrially. That is true, even though we could compete with the German product. The demand for this ware, aside from that going to colleges and universities, would be so little that there would be no inducement for the American manufacturer to go to the expense of equipping himself and making molds for that line. It has also seemed to me that the jobber or dealer was entitled to the trade of the consumer; that is, the trade of the colleges and universities.

J. E. Capen, sales manager of Macbeth-Evans Glass Co.:

FREE CHEMICAL GLASSWARE.

With reference to the duty-free chemical glassware I think I could, perhaps, give you a little different angle. I have talked with a good many of the users of this glass—perhaps I may call them professors—in these schools, and they seem to think that a mistake has been made in allowing this material to come in free. There are two reasons for it. In the first place the schools and institutions are kept up at the expense of our own people in the form of cash donations, endowments, etc. Certainly, in order to obtain this material they must place very large orders, perhaps once a year, and they have to wait weeks and sometimes several months to get it.

They may buy more than they need, or they may not buy enough. They may run out of certain sizes of articles, and they are almost compelled to keep out of them or pay a good deal higher price to get them. Those to whom I have talked, almost all of them, seem to think it would be better if the duty was the same as applied to ware for commercial uses.

OPINIONS OF SCIENTISTS.

Questions addressed to the directors of the chemical departments of universities and other institutions relating to the effect of the withdrawal of the duty-free privilege in the importation of chemical glassware and apparatus and the increased cost to the student elicited replies from some of the most important institutions. The results are embodied in the following summaries and they are followed by interesting views of the individual scientists named.

Question.—Would the withdrawal of the duty-free privilege heretofore enjoyed by educational institutions and the continuance of the present rates of duty on apparatus and chemicals increase the development and manufacture of such merchandise in the United States?

The heads of the chemical departments of 20 universities and scientific institutions replied to this question. The institutions included Yale, Cornell, Pennsylvania, Leland Stanford, Illinois, Pittsburgh, Chicago, Washington and Lee, Ann Arbor, Washington, the Carnegie Institute, Rockefeller Institution, Bureau of Chemistry, Bureau of Standards, Washington Hygiene Laboratory, Geophysical Laboratory, and Pratt Institute.

Of these, 17 stated that the withdrawal of the duty-free privilege would increase the development and manufacture of chemical articles, one said it would have little effect, one answered in the negative, and one was noncommittal.

Of 8 of the principal importers and dealers who replied to the question, 6 answered yes, 1 answered no, and 1 was noncommittal.

Question.—Would such increase benefit the whole chemical industry in the United States sufficiently to justify the loss possibly involved thereby to educational institutions.

Replying to this question, eight scientists stated that the benefit would justify the possible loss, while all of the other university men either thought it would not do so or were doubtful. The importers and dealers, some of whom are manufacturers of lamp-blown and volumetric ware, expressed the opinion that the industry would be sufficiently benefited to justify the possible loss involved.

Question.—What do you estimate the increased cost per student per year under normal conditions which might result from such withdrawal?

The replies of the university men to this question varied. The estimates of increased cost per year per student were as follows: \$3 to \$5; \$5 to \$8; \$5 to \$10; \$10 to \$20; less than \$25; about 25 per cent; probably 50 per cent. A number of educational institutions charge only the actual cost. This additional information was given: "Some schools charge net prices, but the majority add from 100 to 200 per cent to the cost, which was not intended by the Government when the law was passed. In other words, a great many schools compel students to pay the entire operating expenses of the laboratory supply department by adding a profit to the duty-free prices. One large western university pays interest on the equipment of the storeroom and the running expenses of same, including the salary of the purchasing agent, and in addition shows a profit. We do not know of any that charge the actual cost price. The spirit and literal interpretation of the duty-free law has been broken by a great many schools in checking up the apparatus used by instructors and students and allowing the same to be carried away from the institution. Some of the duty-free goods have been disposed of by laboratories.

INDIVIDUAL OPINIONS OF UNIVERSITIY DIRECTORS OF CHEMICAL DEPARTMENTS.

Bertram B. Boltwood, in charge of Sloane Laboratory, Yale University: Our opinions regarding the several questions are as follows: In our opinion a definite distinction should be made between "apparatus" and "chemicals." Chemical apparatus as such may be divided into two classes (1) apparatus proper, including lamp stands, burners, drying ovens, water baths, stills, and similar appliances used in chemical experiments, and (2) utensils, including laboratory glassware, porcelain and earthenware (beakers, jars, funnels, flasks, etc.). The manufacture of chemical apparatus (1) can scarcely be considered as properly a part of chemical industry. The production of these articles, as you know, is mostly in the hands of concerns like Eimer & Amend, the Scientific Materials Co., the Taylor Instrument Co., etc., who have in general supplied American-made rather than imported articles, owing to the fact that for our general uses the home-made articles have usually been preferred. This class of manufacturers have to all appearances prospered sufficiently under existing conditions and would scarcely seem to need any further assistance. With respect to class 2 (utensils), the production of glass beakers, flasks, etc., in this country has been confined almost wholly to concerns engaged in general glass-making who have been able to produce superior articles like Pyrex, Nonsol, etc., glasses which are being used more and more because of their superior qualities. It would hardly seem necessary to further benefit these concerns by removing duty-free importation as they are already sufficiently prosperous with every assurance of a continuation of their trade even in the face of foreign competition. The situation in regard to porcelain is somewhat different, as apparently efforts to produce a superior grade of chemical porcelain in this country have not been successful. The withdrawal of the duty-free privilege of importing porcelain might stimulate the manufacture of a superior grade of porcelain in this country, but the manufacture of both porcelain and glass would hardly, as we understand it, be considered as constituting a branch of the chemical industry.

It would seem that the actual consumption of chemicals in educational institutions was not sufficiently great to be an important factor in the industrial manufacture of these chemicals. With the continued improvement in the quality of inorganic chemicals manufactured in this country there has been an increasing tendency on the part of the Yale laboratories to buy American chemicals and not to import them duty-free from Germany. In the case of organic chemicals, owing to a very limited supply in this country the tendency has been to import from Germany, since this was the only source of supply available. Replying then to your questions: 1. The withdrawal of the duty-free privilege would in all probability tend to increase the development and manufacture of such merchandise in the United States. It would also increase the price to the consumer.

2. Such an increase would not appear to benefit the whole chemical industry in the United States sufficiently to justify the loss inflicted thereby on the educational institutions, with a possible exception in the case of organic chemicals.

3. The estimated increase in cost per student per year under normal conditions would probably be of the order of the rate of duty charged on the various supplies, since the increased cost to the institution due to import duty would ultimately fall upon the student.

4. The effect of the change on the scope and quality of chemical research in the United States would probably be greater than on the routine teaching of chemistry since it is particularly in connection with research work that importations have to be made, owing to the fact that in the past, at least, it has been very difficult to obtain many new forms of apparatus and many of the more unusual chemicals in this country. The effect of the change on chemical research would seem to be distinctly undesirable.

5. The practice prevailing before the war of ordering large quantities of chemical apparatus and reagents in advance of immediate requirements has in our opinion resulted in a great saving rather than in extravagance. Owing to the fact that an excess of equipment over immediate needs had accumulated in a number of laboratories, these laboratories have been in an especially favorable position since the supply of material from the earlier sources has entirely ceased. It seems to us that this accumulation of a surplus stock has been in the nature of a most excellent investment, and, as most chemical apparatus and reagents are not subject to deterioration with age, the supplies accumulated in this way have constituted a genuine asset.

6. The interruption in duty-free importations from Germany coupled with the scarcity and high cost of domestic made apparatus has somewhat restricted the scope of educational and research work in our laboratories here. The funds which may be expended by our laboratories are necessarily limited and the increased cost of material has necessitated a decrease in the quantities purchased. In certain cases where more expensive apparatus might otherwise have been used, it has been necessary to employ cheaper and inferior substitutes. In some cases, work, which might have been carried out under other circumstances, has been abandoned. This necessity for saving money has naturally resulted in greater economy in the running of the laboratory.

7. The general practice has been somewhat different in the two Yale laboratories. In both laboratories, however, the charge to the student for apparatus broken in use has been based upon the replacement value of the article in question. This replacement value has been determined by the price paid for the article by the laboratory on the basis of duty-free cost. In the college there has been annually a surplus balance of laboratory fees plus breakage charges over operating expenses of the laboratory. This balance has been placed to the credit of the college chemical laboratory and constitutes a fund amounting, at the present time, to about $16,000. In the Sheffield Scientific School any surplus balance of this sort has been expended for general expenses of the institution and has not been credited to

the chemical department. The accounts in the Sheffield chemical laboratory have not been kept in such a form as to make it possible to determine what the surplus has amounted to. The total surplus of both departments has certainly been very considerably less than the total laboratory fees (exclusive of breakage charges).

8. In our opinion the quality of glass manufactured in the United States (including Pyrex and Nonsol) is distinctly superior to any glassware previously imported. It is extremely unlikely if market conditions were restored to prewar conditions that any general use of imported glassware would result. As far as our experience goes, the case of porcelain is somewhat different, as the chemical porcelain ware made in this country is distinctly inferior to that previously imported.

9. The value of chemicals used by the chemical laboratories must be but a very small part of the value of the chemicals produced for and consumed by other agencies. It does not seem at all probable that the enforced purchase of chemical supplies in this country would greatly benefit the producers and manufacturers in general.

10. The manufacture of chemical apparatus and chemicals appears to have been quite profitable to those who have engaged in it in this country, even under the prewar conditions. That the chemical industries as a whole can be benefited by increasing the profits of a small group of manufacturers and at the same time placing any restrictions or obstacles whatever in the path of chemical education and research seems altogether contrary to sound reasoning.

11. Chemical teaching and research are without doubt the only practical foundation upon which a successful chemical industry can be erected. Any encouragement and advancement of teaching and research will certainly be to the ultimate advantage of this industry. The present system of duty-free importation for the chemical laboratories of educational and research institutions would seem in effect to constitute at most a very modest tax on certain branches of chemical industry, while at the same time this tax is applied to promoting in a most effective way the best interests of the chemical industry as a whole. It appears, therefore, to be eminently fair and just in its workings. I can not but feel that the imposing of duty on importations of chemicals and apparatus, now admitted duty free, with a special view to the exclusion (after the war) of German products, would be altogether ineffective. I believe that the German manufacturers would still be able to undersell the American producers of certain products in our own markets. A definite understanding and agreement not to buy German supplies *under any circumstances*, when American articles are obtainable, if adhered to conscientiously, would be vastly more effective, and much more in accord with our patriotic sentiments. I, for one, have definitely decided to follow such a policy and I know of a considerable number of other American chemists who are resolved to do likewise.

J. Stieglitz, in charge of laboratory, University of Chicago: In my opinion the wise course to follow would lie between the situation as it was before the war, namely, that educational institutions were relieved of the payment of duty for the importation of scientific apparatus and chemicals, and, on the other hand, that this privilege be simply abolished. I believe that it will be wisest if the American Chemical Society should recommend to the United States Tariff

Commission that this privilege be abolished, but that at the same time the duties be carefully studied and revised when necessary and based essentially on differences in wages as compared with European conditions in such a way that we should have not complete protection for the American manufacturer, but protection based on healthy, brainy, and foresighted competition with European products. Any protection that would make possible poorer work by American manufacturers and give them a monopoly on such a basis would be positively detrimental to the scientific institutions as well as to the industries of the country. In a word, the manufacturers of apparatus, etc., in this country should be put on their mettle with just enough protection to make possible competition on the basis of equal costs and quality. This would be possible in many cases only as the result of the employment of research chemists and physicists, a result which is most highly desirable in all branches of industry in the United States if we are to have any permanent improvement. The reduction in tariffs under the Democratic administration, in my opinion, has had such an effect to a very considerable extent, and even if the war had not intervened and we would have had some years of business depression the ultimate result would have been, I believe, a decided improvement through research and invention in the methods and products of American industry. This applies in the same way to manufacturers of apparatus as to manufacturers of other products. I would further suggest that the Tariff Commission be advised to make a recommendation removing the privilege of free importation at first for a definite period of years only—5 years or, if necessary and on further approval by the commission, 10 years. The idea of this is that the American manufacturers would then feel that they would have to make positive progress in the course of time in order to hold their market. A similar provision, I believe, is in the recommendations concerning dyes and other products.

W. A. Noyes, in charge laboratory, University of Illinois: While there are reasons which I well understand for some restriction in trade between nations which greatly differ in industrial conditions and in the character of their people, reasons of this sort are likely to decrease rather than increase in the future, I can see no logical reason why we should buy a certain line of goods from an American when the same line of goods can be better or more cheaply made in England. I do not expect to see ideals of greater freedom of trade between the countries of the world realized at once, but I think that scientific men ought to do what they can to foster such an ideal.

L. M. Dennis, in charge department of chemistry, Cornell University: Inasmuch as the greater part of chemical apparatus and chemicals now purchased by our universities for their departments of chemistry is used for instruction in elementary courses, the increased cost of the supplies would fall chiefly upon the students taking these courses, since it is customary for the laboratory to require the student to pay for the apparatus and chemicals that he uses in his work.

If conditions after the war should be such as to render it impossible to import apparatus from Germany, chemical research in the United States would suffer through being deprived of such aids to investigation as are not now manufactured in this country and probably would not be manufactured here for some years to come. If, however, such special apparatus could be imported from Germany under high duty, chemical research in the United States would probably suffer but slightly because the total cost of such special apparatus would doubtless not be great.

A university that imported chemical apparatus and chemicals from Germany before the war did so under oath that these supplies were for educational purposes and were not intended for sale. Such being the case, it has been thought by the department of chemistry of Cornell University that a charge to the student for such imported supplies that was in excess of the actual cost of these materials to the university would constitute a violation of our agreement with the Government under which such duty-free importation was permitted. The students were consequently charged the cost price for all imported chemical apparatus and chemicals.

The chemical glassware now made by the leading manufacturers in the United States appears to compare very favorably with the better qualities of laboratory glassware that were formerly made abroad. This fine quality of glassware is, however, not needed in the elementary courses in chemistry in which the greater part of the purchased glassware is used. If, therefore, we are to furnish our students with American-made glassware after the war, it is highly desirable that our manufacturers produce a cheaper grade of ware than they are now making, since otherwise our students would be required to use an expensive line of glassware of much finer quality than is really needed in much of their work. I do not advocate the use of cheap lime-soda glassware, even for elementary work in chemistry, but, if our American glass companies would manufacture beakers and flasks of a glass approximating in quality the "R" glass of Greiner and Friedrichs, the cost, to our students, of glassware of satisfactory grade would be materially reduced and the development of the manufacture of such apparatus in the United States would thereby be substantially encouraged. The material reduction in price that would follow the replacement of expensive resistance glass by a grade like the "R" quality is apparent from a comparison of the prices of a small beaker of "R" glass, of Jena glass, and of one of the best-known grades of American glass. These prices stand in the proportion of 11 to 25 to 54.

The largest purchasers of chemical glassware in this country are the university laboratories of chemistry. If we wish to give the greatest encouragement possible to the manufacture of chemical glassware in this country, it would be necessary to shut off foreign supplies, except at prohibitive rates, from *all* American purchasers. But in this connection it should constantly be borne in mind that whereas a chemical industry can easily meet an increased cost of its laboratory equipment through the profits accruing from its manufacturing, a university is not a money-making institution, and usually contributes in money much more to the education of its students than the students themselves pay. If the increased cost of supplies should fall upon the university, it would constitute a tax upon a benefaction; if it should fall upon the student, it would constitute a tax upon higher education. Nothing, I think, would be more deplorable or have a more injurious effect on the growth and development of American chemical industries than a decided increase in the cost to the student of his professional training, for this would undoubtedly exclude many of our ablest young men from the profession of chemistry.

R. E. Swain in charge laboratory, Leland Stanford University: Nothing is of such importance to the chemical institutions of this country, whether educational, research, or industrial, at the present time as is complete independence of foreign sources of supply of chemical apparatus and pure chemicals. It is not too great a cost to pay, if in the establishing of such industries by protecting them from disastrous foreign competition, it becomes necessary to withdraw duty-free privileges extended to educational institutions.

We have heretofor depended on foreign importation only for such apparatus and pure chemicals as we could purchase abroad at a clear profit. The list changed from year to year as domestic sources improved or became less advantageous in certain lines. On a full-time laboratory course the added cost would probably reach or exceed $10 per year. It is far more important to have domestic glass, porcelain, and instruments of precision than to enjoy relief from the financial cost of import duty.

Simon Flexner, Rockefeller Institute for Medical Research: Looked at in a large way, the requirements of educational institutions are not great enough to warrant chemical industry to make strenuous efforts to supply them aside from other larger demands for the same products.

While the quality of American glass is as good as the Jena glass, the apparatus made from it is inferior, because of the lack in the United States of skilled apparatus makers, glass blowers, etc. After the war, possibly as never before, it will be desirable and important to stimulate discovery in chemistry. The colleges, universities, and research institutions are the sources of the progress. Unless they can train large numbers of students and investigators and make discoveries of their own, the industry will suffer great impairment. In their own commercial interests, therefore, the manufacturers should favor the educational institutions regarding costs, etc., and not make it too difficult for them to draw the best apparatus in point of quality, precision, etc., from anywhere in the world.

It would seem to be the part of wisdom on the part of the American Chemical Society to protect the interests of chemical teaching and research, as well as to promote the interests of chemical industry.

Alexander Silverman, School of Chemistry, University of Pittsburgh: We experience difficulty in securing special apparatus. For example, we can not obtain Plucker tubes containing the rare gases of the zero group, have waited several years for a Hilger spectrograph, can not get delivery on a Morse type optical pyrometer ordered over a year ago, etc. It should be understood that the American manufacturer must include forms of apparatus for which there is a limited demand, unless he wishes the Government to place such items on the duty-free list. The failure to manufacture optical glass for special purposes is probably accounted for by the policy of said manufacturer to make only that which means "large production and good profits." I hesitate to advocate the assessment of a duty on special apparatus which can be bought at reasonable prices abroad.

James Lewis Howe, Washington and Lee University, Lexington, Va.: Am delighted with the Pyrex glass and am inclined to buy it for general use in preference to anything else. Have not seen any satisfactory American laboratory porcelain and am using Japanese to replace our German supply as it becomes exhausted. I do not think the privilege of duty-free importation should be withdrawn.

Ellwood Hendrick, New York: What impresses me in this connection is the irregularity that did occur with duty-free apparatus for purposes of instruction and duty-paid apparatus for original work outside of universities.

I think it very desirable that skilled artisans should be encouraged in this country and the requirements of universities should do this. Then, too, it would encourage the making of apparatus by students, which I think very desirable. Dr. Edward Weston is constantly training a thousand men and women in just such skill.

VIEWS OF IMPORTERS, MANUFACTURERS, AND OTHERS.

Eimer & Amend: The withdrawal of duty-free privilege heretofore enjoyed by educational institutions, would, in our opinion, increase the development of manufacture of such merchandise in the United States, for the following reasons:

Goods can not be manufactured to advantage unless the quantities desired from the factory are large enough. If therefore the Government departments and large colleges order supplies from Europe in sufficient quantities to cover their wants until the coming year, the balance of goods required by industrial laboratories, who order goods in single or dozen quantities, are in most instances too small to make it possible to manufacture.

The whole chemical industry in the United States would be benefited because the apparatus houses will be forced to carry a much greater stock than in times when large orders were imported from abroad, so that much valuable time would be saved to the chemical industry, due to better service. The American factories will then also learn the intricacies of apparatus and instrument making concerning which they have been woefully lacking in times before. It has been almost impossible to find shops and factories where either the management possessed sufficient scientific training to understand what was required or where the workmen possessed sufficient skill.

Central Scientific Co.: We are decidedly of the opinion that the withdrawal of the duty-free privilege and the continuance of a fair rate of duty, would increase the development and manufacture of both chemical apparatus and chemicals in the United States. That is especially true of glassware and porcelain, as we believe the amount used by schools is necessary to increase the volume of our manufacture so as to make it profitable. This is, also, true of some of what might be termed the "rarer" chemicals.

At the present time, we should say that in articles used in any quantities, the American product is superior to that formerly imported from Germany. We believe that the Pyrex glassware is superior to any glassware ever made. We believe that we have one or two grades of porcelain equal to the best imported. When we consider the fact that the large majority of the porcelain imported in this country was what was known as the "German," we would say that the schools, on an average, are using better porcelain to-day than ever before. The same is true of boiling glassware. In the matter of graduated glassware, the average graduated ware of this country is equal to the average that was imported. The same is true of the cheaper grades of thermometers. We can secure in this country normal glassware equal to that abroad but so far the volume has not been worked up sufficiently for the prices to compare favorably with the ones we formerly obtained abroad. In regard to the lamp-blown glassware, this all depends upon the manufacturer. We believe that there is a tendency towards standardization in this country such as we have never had before. We take this stand on account of the experience that we have had with laboratories criticizing glassware that has been made in this country within the last year or so. We believe this to be a good symptom and one that was not present before the war, for we are sure that the word "German" was taken as final by a great many of the laboratories, regardless of the fact of whether the goods came up to standard or not. This criticism has been particularly helpful to the American industries.

Braun-Knecht Heimann: The sale of laboratory ware is limited, consequently manufacturers can not cut down the cost by increased production. As quality is the factor that counts, the industries engaged in manufacturing this ware should receive positive protection extending over a definite number of years in order to encourage them in carrying on the necessary research work to enable them to produce the highest grade product.

Bausch & Lomb Optical: We believe that the increased cost per student per year in the aggregate would be a small item compared to the results achieved in establishing a more extended American industry for so important a scientific field.

We believe that the effect of such a change in the scope and quality of chemical research in the United States would be advantageous, as it would lead to the employment of men trained in this field of work to a much larger extent in the industries.

Replying to the questionnaire another manufacturer said:

We are manufacturing lines of scientific glassware and porcelain of high quality, which are vitally necessary to the control of our chemical and metallurgical industries. Of course, it is no longer necessary to point out to you the intimate relation of these industries to the safety of the Nation and the absolute need of a self-contained policy on the part of our Government in fostering and encouraging all of these industries and their correlates.

These articles were formerly imported from Germany and Austria exclusively and enjoyed free entry into our scientific and industrial schools, and helped to build up the German propagandists' fallacy that everything of scientific value must have the stamp "Made-in-Germany" upon it, not only as it applied to apparatus and equipment, but also as it applied to the origin and finish of scientific education and training.

To our mind this duty-free entry of materials from which our future chemical engineers studied has been responsible for the failure of American brains and capital to compete until it was certain that our home market would be assured to us for the period of the war.

We further hope that the importance of these lines to American safety is being more deeply realized and that our Government will take steps to prevent the free and unobstructed competition of Austria and Germany after the war.

A leading article in Chemical and Metallurgical Engineering (Mar. 1, 1919) presents the following views:

We believe we voice the patriotic sentiment of every educational institution when we say that Congress should repeal that clause of the tariff which permits the duty-free importation of chemicals and apparatus, and thus encourage American industry in its willing efforts to meet our own needs. It may cost more money for a time, but the additional expense will be welcome and we can find solace in the knowledge that we can shortly build up a million-dollar industry where little or nothing existed before. American manufacturers have shown their ability and their readiness immediately to supply our schools with American products. American teachers undoubtedly are ready and willing to patronize them. It remains only for Congress to act, and that should be done speedily before German agents begin to reconstruct their lost markets.

The Journal of Industrial and Engineering Chemistry (February, 1919) says:

For a number of years educational institutions have been given under congressional authority the privilege of importing, duty free, apparatus and chemicals for use in instruction. This is an indirect subsidy to education. It has proved a curse in disguise, for it resulted in a serious disturbance of university affairs when, through the blockade of German ports, former sources of supplies became unavailable. Conditions fully paralleled those in the textile industry, hitherto dependent on foreign dyes. Naturally manufacture of such articles had not proved attractive to capital in this country, nor can we hope for its development so long as this law exists.

Frankly, we do not expect that the privilege will any longer prove of financial benefit to the educational institutions. Germany will have to make the fullest possible use of all export trade to pay war indemnities, higher prices will therefore be charged, and we believe it is safe for American manufacturers to go ahead. Our confidence in that conviction is, however, rudely shaken when we ask ourselves the question: "Would you be willing to put your own funds into such undertakings?"

The Council of the American Chemical Society has recently expressed its conviction in favor of rescinding this legislation. If Congress will act favorably upon this recommendation, American enterprise and skill will bring us another step nearer to economic independence.

The heads of chemical departments of 20 American universities and scientific institutions, in 1918, were asked if the withdrawal of the duty-free privilege, heretofore enjoyed by educational institutions, and the continuance of the present rates of duty on apparatus and chemicals would increase the development and manufacture of such merchandise in the United States. Of the 20, 17 stated that the withdrawal of the duty-free privilege would increase the development and manufacture of chemical articles; 1 said it would have little effect; 1 answered in the negative; and 1 was noncommittal. Of 8 of the principal importers and dealers, 6 answered yes, 1 answered no, and 1 was noncommittal.

Eight of the 20 heads of the chemical departments above mentioned stated that the benefit of the withdrawal of the duty-free privilege to the chemical industry as a whole would sufficiently justify the possible loss to educational institutions, while 12 either thought it would not do so or were doubtful.

LIST OF MANUFACTURERS OF CHEMICAL GLASSWARE.

Corning Glass Works, Corning, N. Y.
Whitall Tatum Co., Millville, N. J.
H. C. Fry Glass Co., Rochester, Pa.
Kimble Glass Co., Vineland, N. J.
Macbeth-Evans Glass Co., Pittsburgh, Pa.
T. C. Wheaton Co., Millville, N. J.
Cambridge Glass Co., Cambridge, Ohio.

LIST OF SHOPS MAKING LAMP-BLOWN AND VOLUMETRIC WARE.

Eimer & Amend, 205 Third Avenue, New York City.
Scientific Materials Co., Pittsburgh, Pa.
Vineland Scientific Glass Co., Vineland, N. J.
F. Pierce Noble Glass Factory, Conshohocken, Pa.
Griebel Instrument Co., Carbondale, Pa.
Louis F. Nafis (Inc.), 544 Washington Boulevard, Chicago, Ill.
A. Daigger & Co., 54 West Kinzie Street, Chicago, Ill.
Sanitary Fermentation Tube & T. Co., Rochester, N. Y.
Globe Graduating Co., Millville, N. J.
Independent Glass Apparatus Co., 7 South Forty-eighth Street, Philadelphia, Pa.
Calta Glass Works, 460 East Ohio Street, Chicago, Ill.
Philadelphia Scientific Glass Works, 1505 North Wanock Street, Philadelphia, Pa.

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